



USER'S GUIDE FOR GPS OBSERVATIONS

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**Requirements and Development Division
Center For Operational Oceanographic Products and Services
National Ocean Service
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1 INTRODUCTION

This User's Guide for GPS Observations for the tidal and water level station bench marks is prepared to support the Center for Operational Oceanographic Products and Services (CO-OPS) GPS Implementation Plan. The field observation procedures are developed in collaboration with the National Geodetic Survey (NGS) and consist of slight modifications of NOAA Technical Memorandum NOS NGS-58, Version 4.3, as described below, to obtain relative accuracy in connecting water level stations to the International Terrestrial Reference Frame (ITRF) coordinate system and the North American Datum of 1983 (NAD 83) coordinate system. Modifications made to NOAA Technical Memorandum NOS NGS-58 guidelines and requirements in this document involve regarding the length of the GPS observations required. This Guide must be used in conjunction with NGS-58.

It is assumed that the field personnel are familiar with the basic operating principles of the GPS equipment, the cable connections and the antenna/tripod setup procedures. A detailed discussion of GPS processing software and processing procedures is outside the scope of this Guide. GPS data collected by CO-OPS will be processed by NGS initially, for a year or two. Once CO-OPS personnel get training and experience, CO-OPS will process GPS data and will provide final products - Receiver Independent Exchange Format (RINEX) data and appropriate forms - to NGS. GPS data collected by contractors or NOAA Ships for hydrographic survey support, or special projects shall be processed by the parties, and final data product - RINEX data and appropriate forms - shall be submitted to CO-OPS which will be forwarded to NGS, as per the contracts, project instructions, statement of work, or as appropriate.

Important notes are shown as bold face in this Guide.

2 EQUIPMENT AND SETUP

High accuracy static differential GPS surveys require a geodetic quality, dual frequency, full-wavelength GPS receiver with a minimum of 10 channels for tracking GPS satellites. A choke ring antenna is preferred, however, any geodetic quality ground plane antenna may be used. More important than antenna type, i.e. choke ring or ground plane, is that the same antennas or identical antennas should be used during the entire observing sessions. If not, a correction for the difference in antenna phase patterns (modeled phase patterns) must be applied. This is extremely critical for obtaining precise vertical results. The antenna cable length between the antenna and receiver should be kept to a minimum when possible; 10 meters is the typical antenna cable length. If a longer antenna cable is required, the cable must be fabricated from low loss coaxial cable (RG233 for up to 30 meters and RG214 over 30 meters).

A fixed height precise GPS antenna tripod is required for this type of a survey. This is a fixed height, 2 meter pole with three adjustable legs, a bulls eye bubble to plumb the antenna, and a magnetic compass to align the antenna to North. These fixed height tripods reduce the chance of introducing an Height of Instrument (HI) “blunder” during the post-processing of the data. There are situations where it may be necessary to use the adjustable precise GPS antenna tripod, such as when a bench mark is elevated above ground level or when using air transportation. The center pole is adjustable on this tripod, therefore, if not fully extended to the 2 meter position, the antenna height is measured with a steel tape (several times) and entered into the receiver and onto the GPS Observation Log Sheet. In fact, even in the 2 meter position, it is recommended that the adjustable tripod be measured to verify the length. There is a screw-on point at the bottom of the center pole of both - the fixed and adjustable tripods - that must be inspected each time the tripod is setup to ensure that the point is tight and not bent. The tripod must be stable during observations; therefore, the tripod legs must be secured, preferably with sand bags.

Antenna set-up is critical to the success of the project. Plumbing bubbles on the antenna pole of the fixed-height tripod must be shaded when plumbness is determined. Plumbing bubbles must be shaded for at least 3 minutes before checking and/or re-plumbing.

The manufacturer, model, and complete serial numbers of all receivers and antennas must be included for each occupation on each station/bench mark observation log sheet as shown in Figure 3.

3 SELECTING BENCH MARKS

All existing station bench marks at operating stations shall be assessed for feasibility of GPS observations, as time and resources permit. **A note shall be made, either in the APP field of the electronic leveling HA file, if electronic levels are used, or on a copy of the published bench mark sheet, stating the suitability of GPS observations for each mark. GPS visibility obstruction diagram as shown in Figure 5 under Section 6 GPS Project Documentation shall also be completed for each mark observed.**

The most desirable bench mark for GPS observations will have 360 degrees of horizontal clearance around the mark at 10 degrees and greater above the horizon. Newly established marks shall be set in locations that have the required clearances, if at all possible. Public property is usually a good location choice. **If a station does not have any marks suitable for GPS observations, and it has been selected as needing GPS observations, a new 3-D rod mark shall be established according to NOS standard procedure.** This new mark shall be connected to the station bench mark network through conventional geodetic leveling, and then GPS observations shall be made.

Regarding suitability of a mark for GPS observations, a review is first made of the historical bench mark information in the station packages and level records (Form 490's), if access to that information via database or if the information is available. Stable marks from the level records are identified and copies of the descriptions and sketches are made. Descriptions and sketches are examined and marks are eliminated that have obvious obstructions, such as vertical marks, marks set several meters from medium to large structures, etc. Do not eliminate marks that are near poles, fences or about 20 meters from small structures at this time during the preliminary planning. If no other mark is available or found suitable, and time does not permit the installation of a new (GPS) mark, it may be necessary to use one of these marks. In selecting a GPS mark, priority should be given to the NWLON Primary Bench Mark or an NGS National Spatial Reference System (NSRS) mark (mark with a NAVD88 height on a NGS datasheet).

If time permits, conduct a site reconnaissance survey prior to starting the GPS sessions, to select the proper mark(s) to occupy with GPS. A site survey consists of preparing an obstruction diagram for each useable mark using an inclinometer and placing a GPS unit (hand-held or better) over the bench mark to determine how many satellites can be tracked at that location. Determine the location of a suitable weather proof location, if any, for the GPS receiver. Measure the distance from the mark to this location to determine the antenna cable length required. Ideal marks should have approximately 360 degree unobstructed visibility above the 10 degree elevation mask. However, for 24-hour tracking, the satellite geometry changes about every 4 minutes, so some obstructions, particularly those to the North of the mark, may not degrade the precision and ultimately the precision or accuracy of the final solution.

Static GPS surveys shall be conducted on a minimum of one bench mark at each water level station in NWLON.

Static GPS surveys shall be conducted at water level stations concurrently with the occupation of NAVD 88 marks, if possible, to accomplish water level datum transfers using GPS-derived orthometric heights.

The station bench mark selected for GPS observations shall have stability code either an A or B. GPS observations on the PBM are preferred if the PBM has the stability code of A or B and also if it is suitable for satellite observations. Stability code C and D bench marks shall not be used for GPS observations unless there are other issues such as security issues, access, or required bench marks with stability codes A or B are not available.

Generally once a mark is selected for GPS observations, future GPS observations shall be done on the same mark. In many states, CO-OPS has provided NGS with lists of selected marks suitable for GPS observations at water level stations, and NGS has completed observations on these marks. It may be necessary to select new GPS marks, or set new marks, at some stations to ensure stability over time as the case may be.

A digital photo of the stamping of the bench mark occupied must be made as shown in Figure 7. If digital photo is not available, then a rubbing of the bench mark must be done as shown in Figure 6. A digital photo is preferred over the rubbing of the mark.

4 DATA COLLECTION

Set the epoch update or recording interval (REC INT) for 15-seconds, which should agree with the recording interval of the reference stations (IGS or CORS) used to post-process the data. For GPS sessions greater than 30 minutes, collect data at 15-second epoch intervals, starting at an even minute. The elevation mask (ELEV MASK) is typically set for 10 degrees for static surveys; low angle satellites can degrade the final solution. Set the minimum number of satellites to four. For static surveying, setting the minimum number of satellites (MIN SV) is not as critical as for kinematic surveying. However, if the number of satellites tracked drops below four, it could be an indication of other problems, such as an antenna or antenna cable connection problem, RF interference, or an obstruction from traffic (vehicle or vessel). The GPS signal from the satellite is not very strong when entering the receiver, so anything that produces further attenuation of the signal can cause the receiver to stop tracking satellites.

The length of GPS observation sessions depends upon the length of the time field crew has available for GPS observations, number of satellites available at a site, number of bench marks available for GPS observations, etc. **The basic requirement for GPS observations on a bench mark is minimum two sessions of 6 hours each and both sessions should begin with proper antenna setup.** The two GPS observation sessions on the same bench mark can be done on the same day or on two different days. When two sessions are done (whether on the same day or on two different days), then close down the antenna at the end of the first session and re-setup the antenna at the beginning of the second session. If two sessions are done on the same day, then start the second session at least after ½ hour after the completion of the first session. If two GPS observation sessions are selected on two different days, then ideally the second session should start 28 hours after the beginning of the first session so that a different set of GPS satellites are available for the second session. When two sessions are done on the same day, the gap between the end of the first session and the beginning of the second session can be or need to be increased if PDOP is not suitable for observations, this is applicable only if PDOP information is available to crew.

For contract and NOAA hydrographic surveys, and special projects three GPS observation sessions of 6 hours each on two or three different days are recommended, if time and resources permit. If three GPS sessions are done then they should be spread over minimum two different days. Two GPS sessions can be done the same day, or on two different days.

If only one GPS observation session is possible for the available time, then record minimum of 24 hours of GPS observations on a bench mark. Minimum two GPS observation sessions of 6 hours each are preferred over one long 24 hour GPS session.

Always collect a little bit of extra data if time and schedule permit, so that blunders or invalid data, if any, can be removed during processing still leaving minimum of 24 hours of valid data for one GPS session, or 6 hours of valid data for each session for two (or three as the case may be) GPS sessions.

It is recommended that after each session is complete, two independent downloads be done from the GPS receiver to the laptop computer, so that if one downloaded file gets corrupted, the other file may have good data. Since two downloads of the GPS observation file is a requirement, do not make copy of the downloaded file twice to the laptop instead, as both the files will have the same problem, if there exists a problem. Send both copies of digital GPS data so that one copy of the data can be forwarded to NGS and other copy will be kept for record in RDD.

Data should be compressed and copied to a CD-ROM, diskette, and/or zip disk, as appropriate, at the end of each GPS day for transporting data from the field to the office, or hotel as the case may be, for processing. If data are logged to a PCMCIA card (flash card) in the receiver, consult the receiver User Reference Guide about re-formatting the card prior to beginning observations.

Data should be collected during periods when the Vertical Dilution of Precision (VDOP) is less than 6 for at least 90% of each 30-minute or longer GPS observations, if VDOP maps or data are available for the site.

4.1 METEOROLOGICAL DATA

Meteorological data (air temperature, barometric pressure, and relative humidity) need to be collected, if available, during the GPS observations. **Meteorological data should be collected at or near the antenna phase center.** All equipment should be checked for proper calibration periodically. Most NWLON stations have air temperature sensor and some NWLON stations are equipped with barometer. **Collect appropriate meteorological data at the beginning, middle, and at the end of each GPS session, if a sensor is available and GPS session length is greater than 2 hours. If a sensor is available, then air temperature must be observed and recorded to the nearest 1° Celsius, and barometer must be observed and recorded to at least nearest 1 millibar.**

If none of the meteorological sensors (air temperature, barometric pressure, and relative humidity) are available for recording observations, then note any change in the atmospheric conditions on the GPS station/bench mark observation log form under Remarks section, as shown in figure 3.

5 GPS PROJECT DOCUMENTATION AND DATA SUBMISSION

The following information shall be submitted to CO-OPS at the end of the project so that proper information can be forwarded to NGS.

This documentation is important because most of the information is used to submit the GPS data to NGS. In addition to the log, data must comply with the “Data Submission to NGS Section” of NGS-58 and the “Input Formats and Specifications of the National Geodetic Survey (NGS) Data Base” to become part of the NSRS.

GPS forms in PDF format can be found at the following NGS Federal Base Network web site:

<http://www.ngs.noaa.gov/PROJECTS/FBN/index.htm>

Refer to Figures 1 through 7 for GPS projects submission checklist and sample package contents.

- (a) Project report (Refer to Figure 1):
One project report per GPS project is required.
- (b) Station (bench mark) description or recovery notes (Refer to Figure 2)
One per bench mark, for which GPS observations are submitted, is required.
- (c) Observation log sheets (Refer to Figure 3 and 4)
One per each GPS observation session is required.
- (d) Station/bench mark visibility diagrams (Refer to Figure 5)
One per each bench mark, for which GPS observations are submitted, is required.
- (e) Photographs or rubbings of station (bench) marks (Refer to Figure 6 and 7)
One per each bench mark, for which GPS observations are submitted, is required.
- (f) Raw GPS data
- (g) Rinex GPS data

5.1 DATA SUBMISSION

Submit all GPS project data and documentation to:
Chief, Requirements and Development Division
CO-OPS, N/OPS1, SSMC 4
1305 East-West Highway, Station 6531
Silver Spring, MD 20910-3233
Tel: 301-713-2897

Figure 1

**PROJECT SUBMISSION CHECKLIST
GPS PROJECTS**

Project Title : _____

Submitting Agency: _____

Observing Agency: _____

Receiver Type: _____

Antenna Type: _____

PACKAGE CONTENTS

- () Project Report
- () Station Description or Recovery notes
- () Observations Log Sheets
 - Data which must be filled out:* Station Designation, Date (UTC), General Location, Day of Year, Project Name, Session ID, Observation Session Times, Agency Full Name, Operator Full Name, Phone Number, GPS Receiver, GPS Antenna, Antenna Height, Data File Name
- () Antenna height measurements
- () Station Visibility Diagrams
- () Photographs or Rubbings of Station Marks
- () Raw GPS data
- () Rinex GPS Data - See below
- () Other

DATA REFORMATTING

Convert the raw GPS data to RINEX2 format with your manufacturer's software. The software should require you to enter the raw data filename, the output filenames, your name, the observer's name and agency, and the antenna type used.

The NGS-standard data filenames are as follows:

Raw GPS input files: aaaaddds.xxx

Where: aaaa = Alphanumeric 4-character station identifier,

ddd = Julian day of the year,

s = session, yy = year of observations,

and xxx is the receiver-dependent file extension (e.g., .DAT, .EPH, .ION, .MES, etc.)

RINEX2 navigation and observation files shall be named as follows.

RINEX2 Navigation File: aaaaddds.yyn

RINEX2 Observation File: aaaaddds.yyo

For example, RINEX2 filenames from station BALD 2 on session A of 12/31/98 are
BALD365A.98o and BALD365A.98n

Copy the raw GPS data files and the converted RINEX2 data files onto separate 3.5-inch diskettes or CD ROM.

Figure 2: Station (Bench mark) Description/ Recovery Form

--> Click here to clear the sample data <--

NATIONAL GEODETIC SURVEY STATION DESCRIPTION / RECOVERY FORM

PID: QE2736 Designation & Alias: BALD 2 RESET
 Country: USA / USA State: OR County: LINCOLN
 Latitude: N 44 49 49.17802 " Longitude: W 124 03 56.23447 " Elevation: 17.0 (meter / ft)

Original Description (check one):		Recovery Description (check one):	
<input type="checkbox"/> P	Preliminary (mark has not been set yet)	<input type="checkbox"/> F	Full description of a station <u>not</u> in the database
<input type="checkbox"/> D	A newly set mark	<input checked="" type="checkbox"/> T	Full description of a station <u>in</u> the database
<input checked="" type="checkbox"/> R	A recovered mark	<input type="checkbox"/> M	<u>Partial</u> description of a station in the database
Established by: (NGS / CGS / Other:) <u>Oregon DOT</u>		Recovered by: (NGS / Other:) <u>Oregon DOT</u>	
Date: _____ Chief of Party (initials): <u>???</u>		Date: _____ Chief of Party (initials): <u>CFS</u>	

Monument Stability (check one):		Recovery Condition (check one):	
<input checked="" type="checkbox"/> A	Of the most reliable nature; expected to hold well	<input checked="" type="checkbox"/> G	Recovered in good condition
<input type="checkbox"/> B	Will probably hold position and elevation well	<input type="checkbox"/> N	Not recovered or not found
<input type="checkbox"/> C	May hold well, but subject to ground movement	<input type="checkbox"/> P	Poor, disturbed, or mutilated
<input type="checkbox"/> D	Of questionable or unknown reliability	<input type="checkbox"/> X	Surface mark known destroyed

Setting Information:		Stamping:	
Marker Type: (Rod / Disk / Other)		<u>BALD 2 1991</u>	
Setting Type: (Bedrock / Concrete / Other:)		Agency Inscription: (NGS / CGS / Other:) <u>Oregon DOT</u>	
<input checked="" type="checkbox"/> N / ? Monument contains magnetic material?		Rod Depth: _____ (meter/ft), Sleeve Depth: _____ (meter/ft)	
		Monument is: (<u>flush</u> / projecting / recessed) _____ (cm/inch)	

Special Type (check all applicable):		Transportation (check one):	
<input type="checkbox"/> F	Fault monitoring site	<input checked="" type="checkbox"/> C	Car
<input type="checkbox"/> T	Tidal Station	<input type="checkbox"/> P	Light truck (pickup, carry-all, etc.)
<input checked="" type="checkbox"/> --	Control Station: (FBN / CON / Bench mark)	<input type="checkbox"/> X	Four-Wheel Drive Vehicle
<input type="checkbox"/> --	Airport Control Station: (PACS / SACS)	<input type="checkbox"/> _	Other (SnowCat, Plane, Boat, describe)
<input checked="" type="checkbox"/> N	Mark is suitable for GPS use?	<input checked="" type="checkbox"/> N	Pack Time (hike) to mark? (hh:mm): <u>00:03</u>

See Back of Form to add Text Description

General Station Location: The station is located in about 10 km south from Lincoln Bay, 13 km north from Depoe Bay, and at the US101 Boiler Bay wayside rest area.

(Describe general location; include airline distances to three towns or mapped features.)

Ownership: The station is on the property of Oregon State Department of Parks and Recreation.

(name, address, phone of landowner)

To Reach Narrative: To reach the station from the intersection of US routes 5 and 101 in Depoe Bay, go north on US 101 for 1 km to the south entrance of the Boiler Bay wayside. Bear left on entrance road for 0.4 km to the parking area on the left. Pack northwest inside fence for about 90 meters to end of fence and the station on the right.

(Leg-by-leg distances and directions from major road intersection to mark)

Monument Description and Measurements: The station is set into drill hole in bedrock, 7.6 m south from the north fence corner, 8.8 m east from the west fence corner, and 3.6 m southeast from the northwest end of the outcrop.

(Add at least three measurements to permanent, identifiable, nearby objects; and a description of the monument size, shape, height, etc.)

NOTE: - Include a pencil rubbing, sketch, or photographs of mark.

Described by: John Q. Surveyor Phone: (301)713-3194 e-mail: jqs@ordot.gov

Figure 3: GPS Station Observation Log

--> Click here to clear the sample data <--


 <p>GPS STATION OBSERVATION LOG (01-Nov-2000)</p>	Station Designation: (check applicable: FBN / <input checked="" type="checkbox"/> BBN / PAC / SAC / <input checked="" type="checkbox"/> BM) BALD 2 RESET		Station PID, if any: QE2736		Date (UTC): 31-Dec-98	
	General Location: Boiler Bay Wayside		Airport ID, if any: ---		Station 4-Character ID: BALD	
Project Name: Sample GPS, 1998		Project Number: GPS- 1234		Station Serial # (SSN): A		
NAD83 Latitude 44 49 49.17802 "		NAD83 Longitude 124 03 56.23447 "		NAD83 Ellipsoidal Height -6.44 meters		
Observation Session Times (UTC): Sched. Start 12:00 Stop 17:30		Epoch Interval = 15 Seconds Elevation Mask = 10 Degrees		NAVD88 Orthometric Ht. 17.0 meters		
Actual Start 11:55 Stop 17:32		GEOID99 Geoid Height -23.52 meters		Agency Full Name: Oregon DOT		
GPS Receiver: Manufacturer & Model: Leica SR530 P/N: p/n 667122 S/N: s/n 0030354 Firmware Version: Version 3.0 <input checked="" type="checkbox"/> CamCorder Battery, <input type="checkbox"/> 12V DC, <input type="checkbox"/> 110V AC, <input type="checkbox"/> Other		GPS Antenna: Manufacturer & Model: Trimble Choke Ring P/N: p/n 29659-00 S/N: s/n 02200-63591 Cable Length, meters: 30 meters Vehicle is Parked 25 meters N (direction) from antenna.		Antenna plumb before session? <input checked="" type="checkbox"/> (Y / N) Circle Antenna plumb after session? <input checked="" type="checkbox"/> (Y / N) Yes or No Antenna oriented to true North? <input checked="" type="checkbox"/> (Y / N) -If no, explain Weather observed at antenna ht. <input checked="" type="checkbox"/> (Y / N) Antenna ground plane used? <input checked="" type="checkbox"/> (Y / N) Antenna radome used? <input type="checkbox"/> (Y / N) If yes, describe. Eccentric occupation (>0.5 mm)? <input type="checkbox"/> (Y / N) Use Any obstructions above 10m? <input type="checkbox"/> (Y / N) Vis. form Radio interference source nearby <input type="checkbox"/> (Y / N)		
Tripod or Ant. Mount: Check one: <input checked="" type="checkbox"/> Fixed-Height Tripod, <input type="checkbox"/> Slip-Leg Tripod, <input type="checkbox"/> Fixed Mount Manufacturer & Model: SECO P/N: none. S/N: 97-G Last Calibration date: 1998-11-01		** ANTENNA HEIGHT ** (see back of form for measurement illustration)		Before Session Begins: measure and record both Meters AND Feet		
		A= Datum point to Top of Tripod (Tripod Height)		2.000		
		B= Additional offset to ARP if any (Tribrach/Spacer)		-0.003		
		H= Antenna Height = A + B = Datum Point to Antenna Reference Point (ARP)				
Tribrach: Check one: <input checked="" type="checkbox"/> None, <input type="checkbox"/> Wild GDF 22, <input type="checkbox"/> Topcon, <input type="checkbox"/> Other (describe) Last Calibration date:		Note: Meters = Feet X (0.3048) Height Entered Into Receiver = 2.000 Meters.		Please note &/or sketch ANY unusual conditions. Be Very Explicit as to where and how Measured!		
Barometer: Manufacturer & Model: pretel altiplus A2 P/N: none. S/N: J.Q.S. Last Calibration or check Date: 11-Sep-01		Weather DATA	Time (UTC)	Dry-Bulb Temp Fahrenheit Celsius	WetBulb Temp Fahrenheit Celsius	
		Before	12:00	74.0	68.0	
		Middle	14:45	77.0	72.5	
		After	17:30	82.5	78.0	
Psychrometer: Manufacturer & Model: Psychrodyne S/N: J.Q.S.		Average of Readings		Calculate		
				Rel. % Humidity		
				74		
				Atm. Pressure inches Hg millibar		
				29.4		
				Weather Codes *		
				00000		
				00001		
				00102		
				* See back of form for codes		
Remarks, Comments on Problems, Sketches, Pencil Rubbing, etc: 1. Winds, calm at start, gradually increased to 20 knots by end of session. 2. Semi-trailer parked 12 meters SSE of antenna from 15:17 to 15:32 UTC, possibly blocking satellites and causing multipath environment. 3. Center pole of tripod projected 3 mm into dimple of disk. Antenna height was therefore 2 m - 3 mm = 1.997 m Note: Entries are Required in all Unshaded areas.						
Data File Name(s): BALD365A.dat (Standard NGS Format = aaaaaddss.xxx) where aaaa=4-Character ID, ddd=Day of Year, s=Session ID, xxx=file dependant extension			Updated Station Description: <input checked="" type="checkbox"/> Attached <input type="checkbox"/> Submitted earlier Visibility Obstruction Form: <input checked="" type="checkbox"/> Attached <input type="checkbox"/> Submitted earlier Photographs of Station: <input checked="" type="checkbox"/> Attached <input type="checkbox"/> Submitted earlier Pencil Rubbing of Mark: <input checked="" type="checkbox"/> Attached		LOG CHECKED BY: JGE	

Figure 4: GPS Antenna Height Measurements

ILLUSTRATION FOR ANTENNA HEIGHT MEASUREMENTS:

I. Instructions for Fixed-Height Tripods:

Measure & record the fixed-height tripod length (A) and other offsets, if any, between the tripod and the Antenna Reference Point (ARP) (B)

$$\text{Antenna Height} = H = A + B$$

II. Instructions for Slip-Leg Tripods:

1. Measure the Slant Height (S)

Measure the slope distance from the mark to at least three notches on the Bottom of Ground Plane (BGP) using two independent rulers (e.g., metric and Imperial). Record measurements in the table below, and compute the average.

Measure S	Notch #_	Notch #_	Notch #_	Average
Before, cm	223.40	223.30	223.30	
Before, inch	87.95	87.94	87.93	
After, cm	223.40	223.40	223.30	
After, inch	87.97	87.96	87.95	
Note: cm= inch x (2.54)		Overall average, cm		

S = _____ cm

2. Record the Antenna Radius (R) and the Antenna Constant (C)

The antenna radius (R) is the horizontal distance from the center of the antenna to the measurement notch. The antenna constant (C) is the vertical distance from the ARP to the BGP. Consult your antenna users manual for exact measurements.

R = 19.05 cm

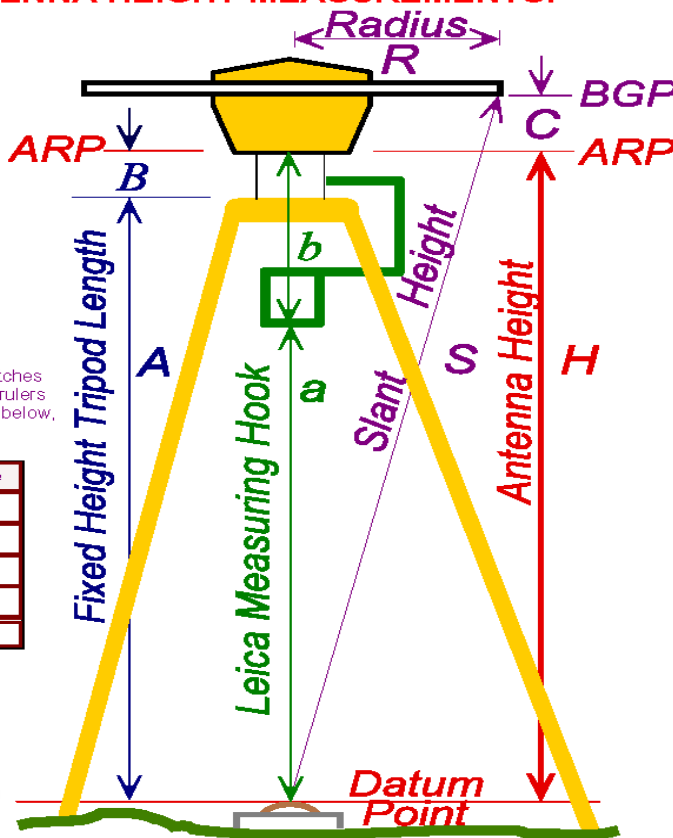
C = 3.50 cm

3. Compute Antenna Height (H)

Use the following Pythagorean equation:

$$\text{Antenna Height} = H = ((\sqrt{S^2 - R^2}) - C)$$

$$\text{Antenna Height} = H = a + b$$

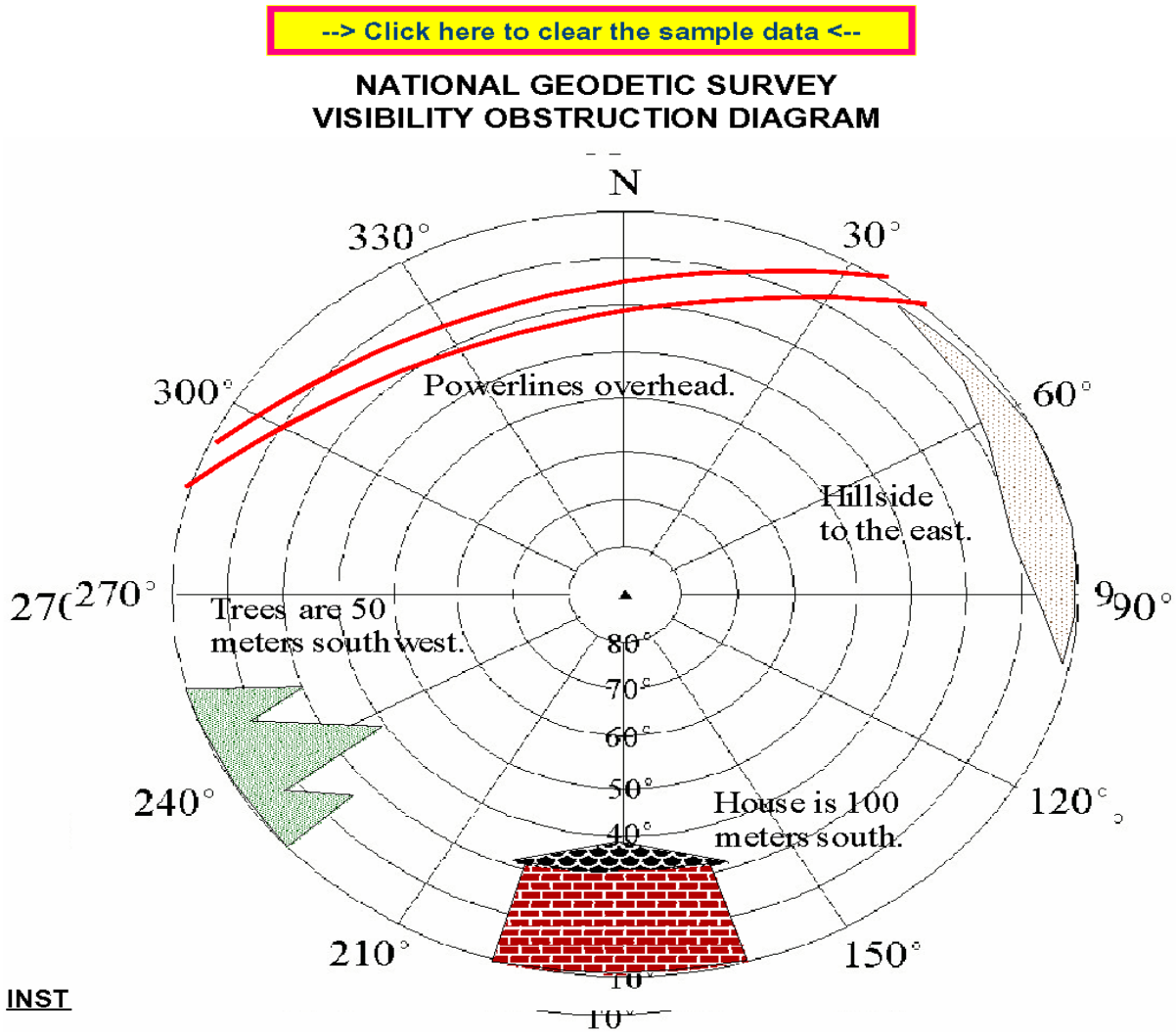


III. Instructions for using the Leica Brand Measuring Hook:

Follow the Leica operating instructions, being sure to reduce the height to the Antenna Reference Point (ARP), NOT the L1 Phase Center.

Table of Weather Codes -- for entry into Weather Data Table on front of form:					
CODE	PROBLEM	VISIBILITY	TEMPERATURE	CLOUD COVER	WIND
0	NO PROBLEMS encountered	GOOD More than 15 miles	NORMAL 32° F to 80°F	CLEAR Below 20%	CALM Under 5mph (8km/h)
1	PROBLEMS encountered	FAIR 7 to 15 miles	HOT Over 80°F (27 C)	CLOUDY 20% to 70%	MODERATE 5 to 15 mph
2	-- NOT USED --	POOR Less than 7 miles	COLD Below 32° F (0 C)	OVERCAST Over 70%	STRONG over 15mph (24km/h)
Examples: Code 00000 = 0 - No problems, 0 - good visibility, 0 - normal temperature, 0 - clear sky, 0 - calm wind Code 12121 = 1 - Problems, 2 - poor visibility, 1 - hot temperature, 2 - overcast, 1 - moderate wind					

Figure 5: Visibility Obstruction Diagram



Designation: BALD 2 RESET PID: QE2736

Location: Boiler Bay Wayside County: LINCOLN

Reconnaissance By: John Q. Surveyor Height above mark: 2 Meters

Agency/Company: Oregon DOT Phone: (301) 713-3194 Date: 1998-12-31

Figure 6: Station Pencil Rubbing Form


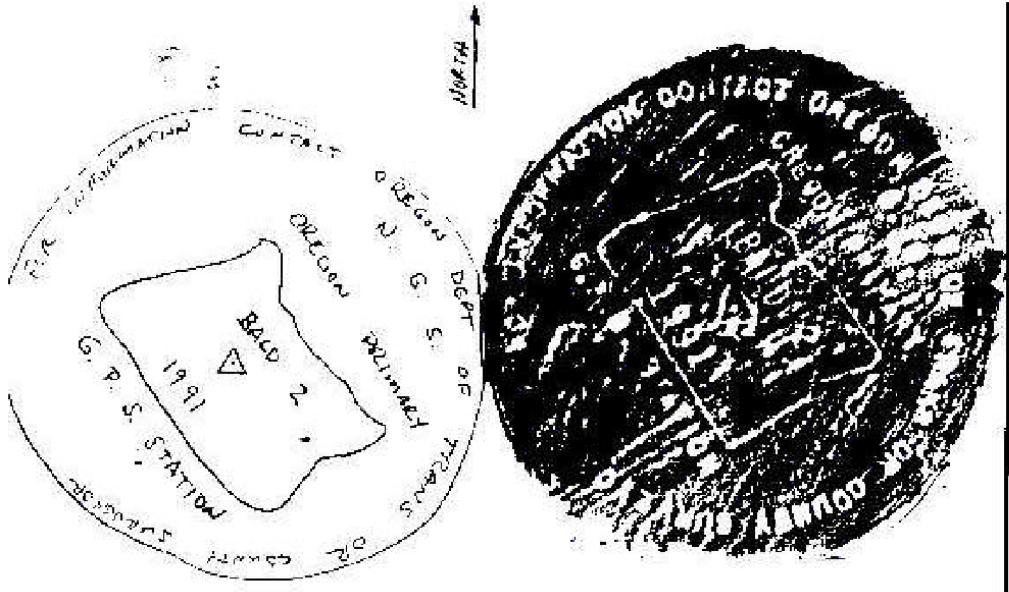
		<h2 style="text-align: center;">Station Pencil Rubbing Form</h2>	
--> Click here to clear the sample data <--			
Location / Airport Name and ID _____		Project _____	
Station Designation _____		PID _____ Date _____	
Circle all applicable: PACS SACS <input checked="" type="checkbox"/> FM FBN <input checked="" type="checkbox"/> OTHER _____		Observer & Organization _____	
Station Pencil Rubbing			
<p><u>Instructions:</u> Place the blank form (or other blank paper) over the mark and rub over the entire disk with a pencil. For rod marks, rub only the designation and date stamping from the rim of the aluminum logo cap. If it is impossible to make a rubbing of the mark, or if the rubbing appears indistinct, a sketch and/or photograph may be substituted.</p>			
			
Remarks: This disk is reset into the same drill hole as the original station BALD 1962.		Monument Type _____ Brass Disk _____	
		Inscribed Agency _____ Oregon DOT _____	
		Stamping _____ BALD 2 1991 _____	



Figure 7: Digital Photograph of a Stamping of a Bench Mark